

MI primer for NuMI users

- Getting beam
- TLG modules
- Timelines
- Beam intensity
- NuMI kickers
- Extraction bumps and last turn positions
- Batch positions and bunch rotation (LLRF settings)
- Beam quality inputs to NuMI BPS
- Caveats

Getting beam

- Make sure that NuMI beam-line gate valves are open
- NuMI extraction timing
 - I:MINX=1.2394 (delay of \$74 with respect to \$A5)
 - I:K6NKD0=20.04932 MI Rev. (fine kicker timing with respect to \$74)
 - I:ACUP23=1.2599 (Abort kicker cleanup)
- Adjust the batch intensity of event \$19 on page B4 to the desired value
- Start a Fast Time Plot showing I:BEAM (beam in MI in units of 10^{12}), I:TOR003 (toroid in MI abort line), E:TOR101, E:TORTGT
- Load the relevant TLG module
 - ask the crew chief to load the appropriate module
 - **the number of batches is an adjustable parameter inside the TLG module (the crew chief has full control of this parameter)**
- Set the NuMI beam switch to ON to get beam in MI

TLG modules

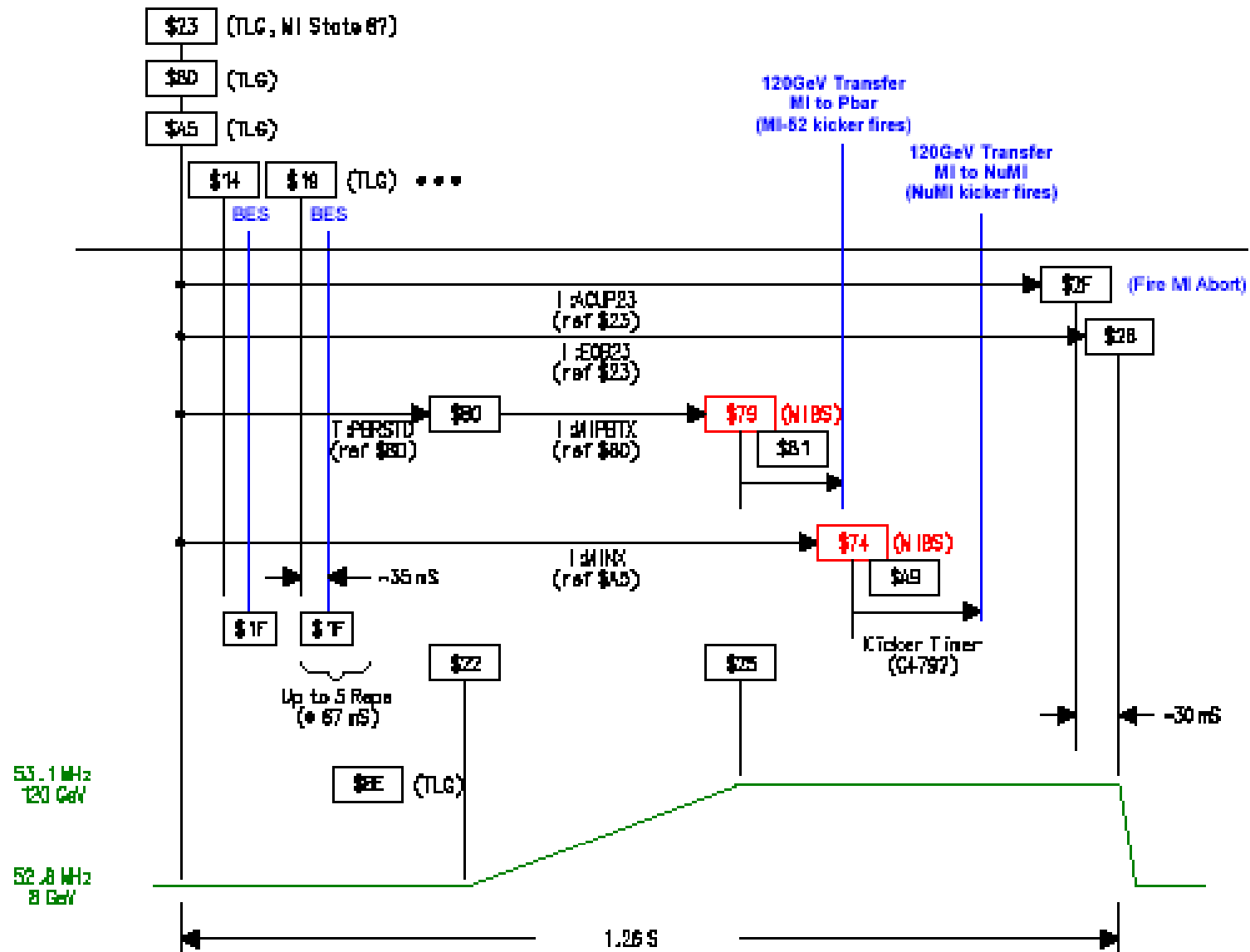
Studies

Description	TCLK events	MI state	Ramp File (I2)	RF File (I3)	TLG module
NuMI cycle to MI abort	\$19, \$23	8	1	2	55
NuMI and slip-stacking to MI abort	\$14, \$19, \$23	5	1	2	79

Operational

Description	TCLK events	MI state	Ramp File (I2)	RF File (I3)	TLG module
NuMI cycle only (1-6 batches)	\$19, \$23, \$A5	21	1	2	73
Pbar stacking and NuMI	\$14, \$19, \$23, \$8D, \$8E, \$A5	7	1	2	72
Slip-stacking and NuMI	\$14, \$19, \$23, \$8D, \$8E, \$A5	5	1	2	68

Timeline for NuMI + pbar stacking



How to change beam intensity/batch

B4 **Booster Beam Turns Control** ♦COPIES♦♦Pgm_Tools♦

```
*SA♦ X-A/D  X=TIME      Y=I:RFSUM ,I:IBEAMM,I V641I ,I V641
---- Eng-U   I= 0        I= 0        , 0        , 0        ,-40
s_MI AUTO    F= 1.2      F= 4        , 8        , 12        , 40
```

<*Transition Times>

Booster Beam Turns Control							
CYCLE	CLOCK	Notch<ON>	BEAM			BUNCHES	MI
TYPE	EVENT	Trig <ON>	TURNS		GAMMA T	TO MI	Bkt
Tev Fix	13	<OFF>	-< 2 >+		<OFF>	<84>< 0>	
PB Prod	14	<OFF>	-< 9 >+		<OFF>	<84>< 0>	
Collidr	15	<OFF>	-< 10 >+		<OFF>	< 7>< 0>	
PB Tune	16	<OFF>	-< 1 >+		<OFF>	< 7>< 0>	
Boo Std	17	<ON>	-< 1 >+		<OFF>	< 0>< 0>	
<u>Studies</u>	19	<OFF>	-< 1 >+		<OFF>	<84>< 0>	
MI Stud	1C	<ON>	-< 1 >+		<OFF>	< 5>< 0>	
Mini Bn	1D	<ON>	-< 9 >+		<OFF>	<84>< 0>	

RAMP POINTER SET TO 1

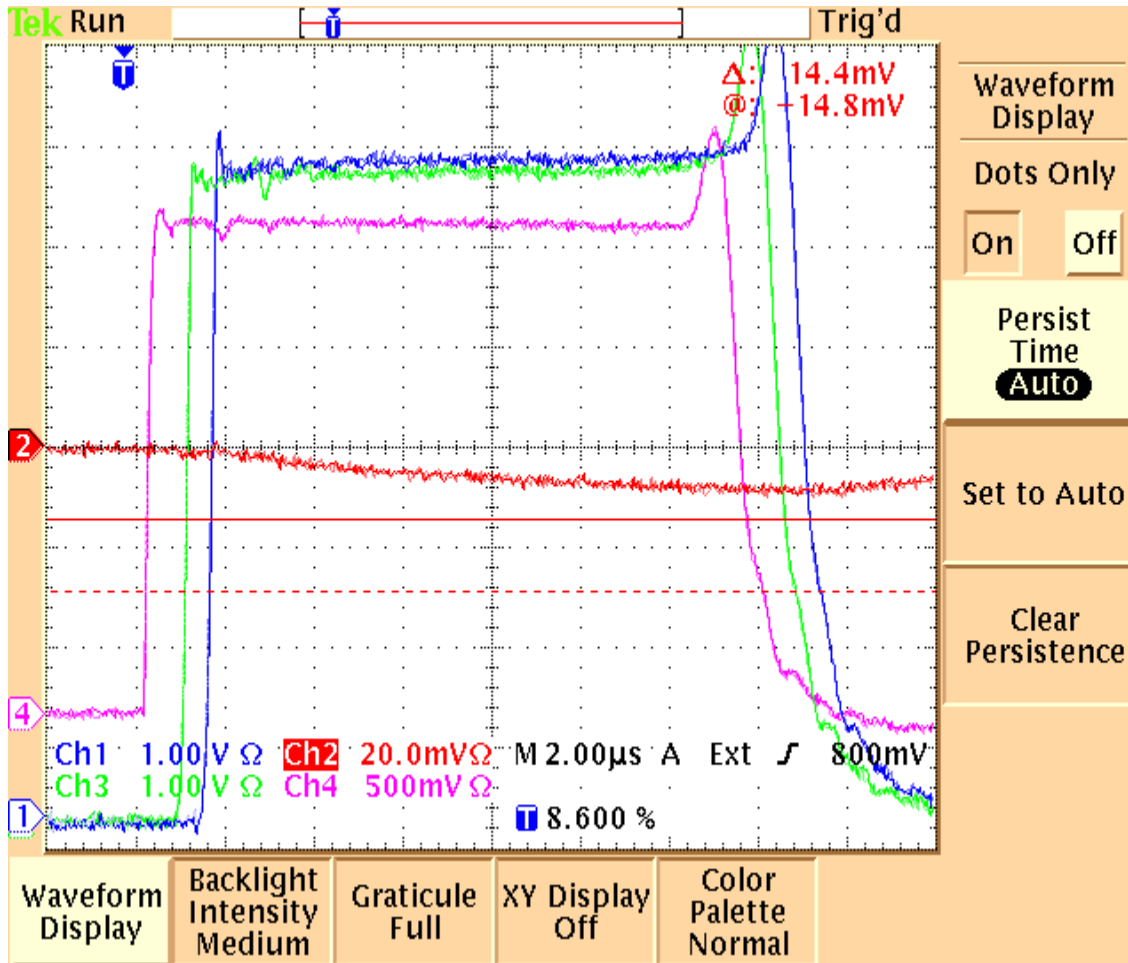
NuMI

*Kicker Times to Lx
*Setup ♦

Please communicate to the Crew Chief that you are going to change the intensity on \$19

NuMI kickers

<http://mi60kicker.fnal.gov/>



- I:KPS6NS
 - scale factor (nominal 1)
 - not enough resolution
- I:KPS6NK
 - HV adjustment (kV)

CH1: KM602A CH3: KM602B CH4: output of
power supply CH2: HP602

Extraction bumps and last turn positions

PA:I65 MI INJ/EXT PARAMS					
I65	NUMI EXTRACTION BUMPS	SET	D/A	A/D	Com-U ♦PTools♦
-<FTP>+ *SA* X-A/D X=TIME Y=I:BEAM I:PHIS I:RPOS I:RFSUM					
COMMAND BL-- Eng-U I= 0 I= 0 -30 -4 0					
-<10>+ s_MI AUTO F= 1.3 F= 2 130 4 4					
8g p/extr. 120 pbprod 120 slow 150 p/ext. NUMI EXTTRT 150.pb/ext					
H604	[6]:3				
-I:H6025	[6]*.1 02 Scale Factors	-10.07	.1	Amps	...
-I:H6045	[6]*.00553Scale Factors	-2.191	.704	Amps	...
-I:H6065	[6]*.09998Scale Factors	-4.328	1.963	Amps	...
H608	[6]:3				
-I:H6065	[6]*.1 06 Scale Factors	-4.328	1.963	Amps	...
-I:H6085	[6]*-.01156Scale Factors	9.695	.943	Amps	...
-I:H6105	[6]*.11622Scale Factors	9.91	1.978	Amps	...
H610	[6]:3				
-I:H6085	[6]*.1 08 Scale Factors	9.695	.943	Amps	...
-I:H6105	[6]*.02428Scale Factors	9.91	1.978	Amps	...
-I:H6125	[6]*.10424Scale Factors	13.95	.152	Amps	...
H602	[6]:3				
-I:H5325	[6]*.1 32 Scale Factors	1.094	-.13	Amps	...
-I:H6025	[6]*-.00542Scale Factors	-10.07	.1	Amps	...
-I:H6045	[6]*.08414Scale Factors	-2.191	.704	Amps	...
H606	[6]:3				
-I:H6045	[6]*.1 04 Scale Factors	-2.191	.704	Amps	...
-I:H6065	[6]*.00206Scale Factors	-4.328	1.963	Amps	...
-I:H6085	[6]*.11748Scale Factors	9.695	.943	Amps	...
V605	[6]:3				
-I:V6035	[6]*.1 03 Scale Factors	0	-.981	Amps	...
-I:V6055	[6]*-.00707Scale Factors	0	-.021	Amps	...
-I:V6075	[6]*.09999Scale Factors	0	.166	Amps	...

PC:E38 NuMI Params					
E38	BPMS IN MI	SET	D/A	A/D	Com-U ♦PTools♦
-<FTP>+ *SA* X-A/D X=TIME Y=I:BEAM I:PHIS I:RPOS I:BLMON					
COMMAND BL-- Eng-U I= 0 I= 0 -30 -4 0					
-< 2>+ s_MI AUTO F= 1.3 F= 2 130 4 12					
mons h20 trms kick beam loss BPMS horn bnds quad vacu pmpa mtrs					
E:HI602	NBpm beam intensity			20.82	sum
E:HP602	NBpm beam position			-.141	mm
E:HP602 [1]	NBpm beam position			-.141	mm
E:HP602 [2]	NBpm beam position			.089	mm
E:HP602 [3]	NBpm beam position			.089	mm
E:HP602 [4]	NBpm beam position			.089	mm
E:HP602 [5]	NBpm beam position			.089	mm
E:HP602 [6]	NBpm beam position			.089	mm
I:HP602	MI HORZ POSITION AT Q602			-26.63	MM
E:HP604	NBpm beam position			-29.54	mm
E:HP604 [1]	NBpm beam position			-29.54	mm
E:HP604 [2]	NBpm beam position			-.593	mm
E:HP604 [3]	NBpm beam position			-.593	mm
E:HP604 [4]	NBpm beam position			-.593	mm
E:HP604 [5]	NBpm beam position			-.593	mm
E:HP604 [6]	NBpm beam position			-.593	mm
I:HP604	MI HORZ POSITION AT Q604			-26.46	MM
E:VP605	NBpm beam position			5.711	mm
E:VP605 [1]	NBpm beam position			5.711	mm
E:VP605 [2]	NBpm beam position			.257	mm
E:VP605 [3]	NBpm beam position			.257	mm
E:VP605 [4]	NBpm beam position			.257	mm
E:VP605 [5]	NBpm beam position			.257	mm
E:VP605 [6]	NBpm beam position			.257	mm
I:VP605	MI VERT POSITION AT Q605			-43.01	MM
E:HP606	NBpm beam position			-1.488	mm
E:HP606 [1]	NBpm beam position			-1.488	mm
E:HP606 [2]	NBpm beam position			-.013	mm
E:HP606 [3]	NBpm beam position			-.013	mm
E:HP606 [4]	NBpm beam position			-.013	mm
E:HP606 [5]	NBpm beam position			-.013	mm
E:HP606 [6]	NBpm beam position			-.013	mm
I:HP606	MI HORZ POSITION AT Q606			-28.72	MM

PC:E38 NuMI Params					
E38	BPMS IN MI (CONT)	SET	D/A	A/D	Com-U ♦PTools♦
-<FTP>+ *SA* X-A/D X=TIME Y=I:BEAM I:PHIS I:RPOS I:BLMON					
COMMAND BL-- Eng-U I= 0 I= 0 -30 -4 0					
-< 2>+ s_MI AUTO F= 1.3 F= 2 130 4 12					
mons h20 trms kick beam loss BPMS horn bnds quad vacu pmpa mtrs					
E:HI608	NBpm beam intensity			40.15	sum
E:HP608	NBpm beam position			19.71	mm
E:HP608 [1]	NBpm beam position			19.71	mm
E:HP608 [2]	NBpm beam position			.3	mm
E:HP608 [3]	NBpm beam position			.3	mm
E:HP608 [4]	NBpm beam position			.3	mm
E:HP608 [5]	NBpm beam position			.3	mm
E:HP608 [6]	NBpm beam position			.3	mm
I:HP608	MI HORZ POSITION AT Q608			-13.74	MM

LLRF settings, state 21 (NuMI only)

I6 VXI LLRF Novice Mode (most restrictive) 09-FEB-05 16:24:24 ♦Pgm_Tools♦

SEQUENCE TABLE VIEWER CURVES ARRAYS required data

Sequence Table View

HrdwrID: [MILLRF] *Send To Hardware *Refresh

MI State: [21 Numi 6 batches] Current state: 28

ROW	TYPE	SIGNAL	MESSAGE	DATUM1	DATUM2	DATUM3	DATUM4
0	Event	AnyReset	EnergyStepToFset	52811400			
1	Continue		EnergyArmATC	-3	3048000		
2	Continue		XfrSyncBoosterToMI	122	80	-33	
3	Continue		SetPhisFrontEndAtten	36	22		
4	Event	BooPInject	QdotfbOn			0	8Gev LPF
5	Continue		XfrSyncBoosterToMI	208	80	0	
6	Event	BooPInject					
7	Continue		XfrSyncBoosterToMI	294	85	0	
8	Event	BooPInject					
9	Continue		XfrSyncBoosterToMI	380	85	0	
10	Event	BooPInject					
11	Continue		XfrSyncBoosterToMI	466	85	0	
12	Event	BooPInject					
13	Continue		XfrSyncBoosterToMI	552	85	0	
14	Event	BooPInject					
15	Delay	0.4620000124	EnergyQrpfB	-5	-20000	.1	A11 DSR
16	Delay	1.1499999762	EnergyQrpfB	-2	-2000	.1	A11 DSR
17	Delay	1.1599999666	QdotfbOn			0	8Gev LPF
18	Delay	1.1699999571	EnergyRampToFset	53103480	.02		
19	Delay	1.2364861965	QcpFwa	5	Disable		
20	Event	EndCycle					
21							
22							
23							
24							
25							
26							
27							
28							
29							

bunch rotation

batch positions

LLRF settings, state 7 (pbar stacking + NuMI)

I6 VXi LLRF Novice Mode (most restrictive) 09-FEB-05 16:23:20 ♦Pgm_Tools♦

SEQUENCE TABLE VIEWER

CURVES

ARRAYS

required data

Sequence Table View

HrdwrID: [MILLRF] *Send To Hardware *Refresh

MI State: [7 Pbar Stacking and NuMI Target

] Current state: 28

ROW	TYPE	SIGNAL	MESSAGE	DATUM1	DATUM2	DATUM3	DATUM4
0	Event	AnyReset	EnergyStepToFset	52811400			
1	Continue		XfrSyncBoosterToMI	0	80	-33	
2	Continue		SetPhisFrontEndAtten	36	22		
3	Continue		EnergyArmATC	-3	3048000		
4	Continue		Scope Trigger 1				
5	Event	BooPInject	QdotfbOn			0	8Gev LPF
6	Continue		XfrSyncBoosterToMI	122	80	0	
7	Event	BooPInject					
8	Continue		XfrSyncBoosterToMI	208	85	0	
9	Event	BooPInject					
10	Continue		XfrSyncBoosterToMI	294	85	0	
11	Event	BooPInject					
12	Continue		XfrSyncBoosterToMI	380	85	0	
13	Event	BooPInject					
14	Continue		XfrSyncBoosterToMI	466	85	0	
15	Event	BooPInject					
16	Delay	0.4620000124	EnergyQrpfb	-5	-20000	.1	A11 DSR
17	Delay	1.1499999762	EnergyQrpfb	-2	-2000	.1	A11 DSR
18	Delay	1.1599999666	QdotfbOn			0	8Gev LPF
19	Delay	1.1699999571	EnergyRampToFset	53103480	.02		
20	Delay	1.2364861965	QcpFwa	5	Enable		
21	Event	EndCycle					
22							
23							
24							
25							
26							
27							
28							
29							

Messages

Beam quality inputs to NuMI BPS

A. Godley, S. Mishra “Description of the ACNET devices that control the Main Injector inputs to the NuMI Beam Permit System”, Beams-doc-1527

- Pbar beam not present in NuMI kicker gap
 - batch-by-batch intensity monitor settings on page I65, sub-page NUMI EXTRT, pages 20-21. The system provides:
 - an analog signal I:BNKG, proportional to the amount of beam in the gap, connected to NuMI BPS module 60S C204, channel 6
 - a digital signal (beam present/no present), generated in response to the timing signal I:BNKGST, connected to NuMI BPS module 60S 200, channel 5
- MI beam Loss Monitors
 - 2 BLMs at Q608 and Q612 (I:LMQ608, I:LMQ612) are used to monitor beam losses at flattop and abort the beam if losses are higher than some preset value
 - controls (reset, hold) and readout signals are available on page E38, sub-page LOSS, pages 4 (reset and hold) and 7 (readout)
 - connected to NuMI BPS module 60A C204, channels 0-1

■ MI orbit verifier

- uses I:HP606N, I:HP608N, I:VP607N, I:VP609N to determine if beam position is on the desired orbit before NuMI extraction
 - connected to NuMI BPS module 60A C204, channels 54-57
- I:HI606N, I:HI608N, I:VI607N, I:VI609N (proportional to the beam intensity) have been used in NuMI BPS to set an upper limit on acceptable pulse intensity
 - connected to NuMI BPS module 60A C204, channels 59-62

Caveats

- The present BPM system does not support 6 batches loaded in MI, at least not for the configuration foreseen for mixed-mode (pbar stacking + NuMI) running
 - to take an orbit in MI, tuning, etc. ..., we need to temporarily remove one of the NuMI batches
- The pbar batch and the NuMI batches occupy fixed bucket positions in MI, and in principle it is possible to control either portion of the beam with its own “beam switch” (pbar and NuMI beam switches)
 - due to the fact that slip-stacking generates beam outside the proper pbar batch in the machine, in the mixed mode cycles NuMI (or pbar) will get beam only when BOTH pbar and NuMI beam permits are ON.